MA

Intel® Pentium® 4 Processor in the µPGA Form Factor

Intel Reference Surface-Mount Process

MA

Disclaimer

Information in this document is provided in connection with Intel products.No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document. Except as provided in Intel's Terms and Conditions of Sale for such products, Intel assumes no liability whatsoever, and Intel disclaims any express or implied warranty, relating to sale and/or use of Intel products including liability or warranties relating to fitness for a particular purpose, merchantability, or infringement of any patent, copyright or other intellectual property right. Intel® may make changes to specifications and product descriptions at any time, without notice.

The Intel® Pentium® 4 Processor SMT may contain design defects or errors known as errata which may cause the product to deviate from published specifications. Current characterized errata are available on request. All dates, products, and plans are preliminary and subject to change.

Any recommended operating methods are correct to Intel's reasonable knowledge at the time of writing. Intel accepts no liability for the implementation of these methods within the customer's manufacturing environment.Furthermore, any named third party suppliers are provided for information only. Intel accepts no liability for the quality of third party suppliers and cannot guarantee the correct or suitable operation of third party products.The hardware vendor remains solely responsible for the design, manufacture, sale, and functionality of its product, including any liability arising from product infringement or product warranty.

Each hardware vendor is responsible for providing their respective product data. Intel does not supply vendor test results, product specifications, price projections, or schedules.The hardware vendor remains solely responsible for the design, sale and functionality of its product, including any liability arising from product infringement or product warranty and Intel assumes no liability for vendor products, either alone or in combination with Intel products.

Intel and Pentium are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries. Fair use of Intel's trademarks in advertising and promotion of Intel products requires proper acknowledgement. * All other brands and names are property of their respective owners.

intel®

Typical SMT/THT Manufacturing Line

- Intel SMT reference process
  - Screen Printer: DEK 265
  - Paste Metrology: SVS 1100 (development tool)
  - Pick and place tool: Fuji IP3
  - Reflow Oven: Atmos 2000
  - Post Reflow Inspection
    - » Visual Inspection
    - » X-Ray: Nicolet 1400 (development tool)
  - Rework: SRT Summit 1000/1100
- SMT equipment and board changes will affect reflow process - characterization is necessary by the OEM
- Customer must conduct experimentation to characterize, stabilize and optimize their own process.

SMT Process Recommendations

- Motherboard Layout Recommendations
  - Minimum land pattern diameter: 20 mil
  - Metal or solder mask defined pads: 20 mil
  - Board surface finish: Hot Air Solder Level (HASL)
  - Socket can only be reflowed right side up (No inverted socket reflow)

- Socket Vendors
  - Foxconn - 478 pin 50 mil pitch BGA (validated)
  - AMP - 478 pin 50 mil pitch BGA (validated)
  - Molex - 478 pin 50 mil pitch BGA (validation pending)

Note: All sockets are already balled with Sn/Pb eutectic solder.

SMT Process Recommendations

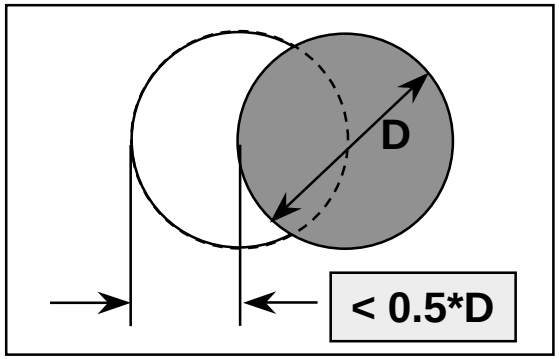
- **Screen Print Process - DEK 265**
  - Solder Paste
    - » Kester R244 Solder paste (Sn63/Pb37)
    - » No clean fluxes are recommended
  - Paste Stencil
    - » thickness: 0.005” or 0.006” - BGA sockets only
    - » aperture: 1:1
    - » chemical/laser-etch with electropolish
  - Screen Print Considerations:
    - » Good gasketing between the stencil and pad
    - » Good print registration
    - » Frequent automatic underside stencil wiping
    - » Proper stencil design - Aspect Ratio $\geq$ 1.5
      - ¤ **Trapezoidal cut with electropolish**

SMT Process Recommendations

- Screen Print Considerations (Cont.):
  - » Good paste deposition
  - » Adequate board support
  - » Squeegee pressure high enough to wipe the stencil clean
  - » Appropriate squeegee speed to ensure paste rolling action
  - » Clean stencil apertures after pauses in printing (prevent clogged apertures)

SMT Process Recommendations

- Placement - Fuji IP3
  - Packaging media - tape and reel
  - Placement nozzle – 10 mm cylindrical stainless steel metal
  - Vision Algorithm - Front light/ ball field recognition
  - Placement tolerance - 50% of pad (offset by no more than 0.5 x diameter).
    - » Limited self-centering during reflow.

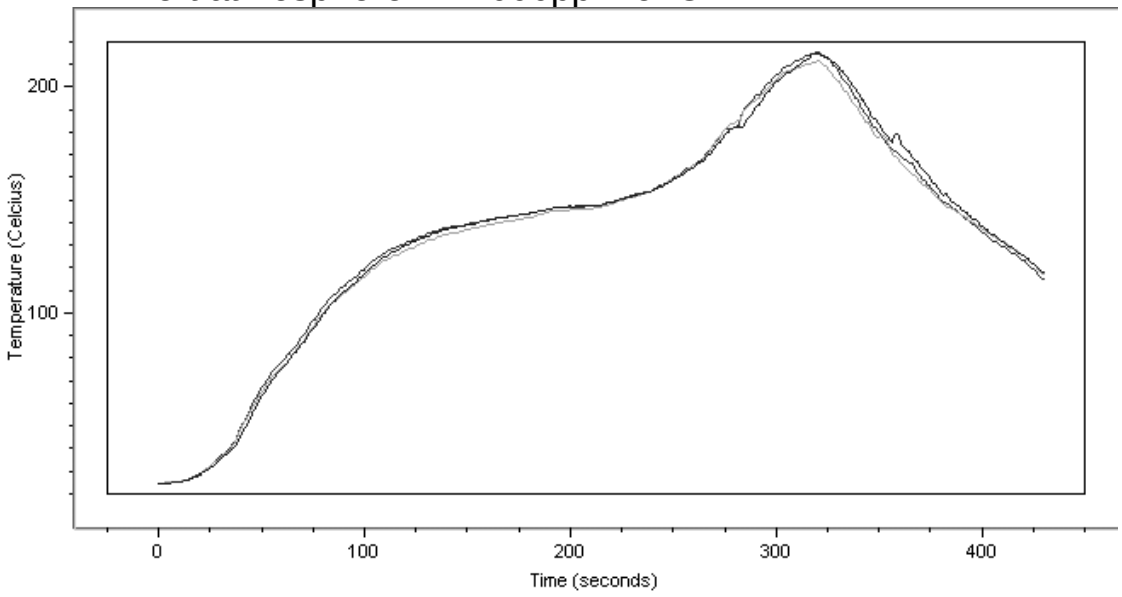


SMT Process Recommendations

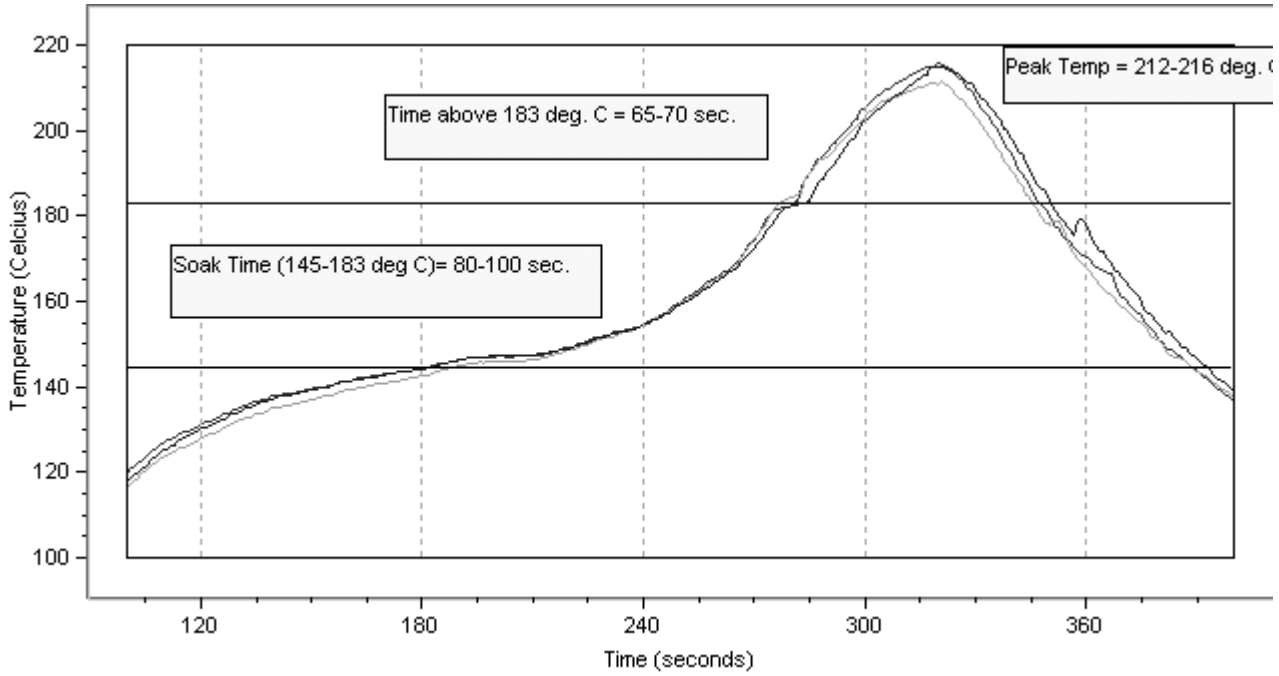
- Example Reflow Oven settings - ATMOS 2000:

(Typical, actual Output Equivalence Requirements for this specific paste are on page: 19 of this section)

  - » BELT SPEED: 78 cm/min
  - » PEAK TEMP: 212 - 216 C
  - » Time above liquid: (183 DEG C) 65-70 SEC
  - » RISING SLOPE < 3.0 DEG/SEC
  - » SOAK 80-100 SEC (145-183 DEG C)
  - » N2 inert atmosphere: < 1000ppm of O2



SMT Process Recommendations



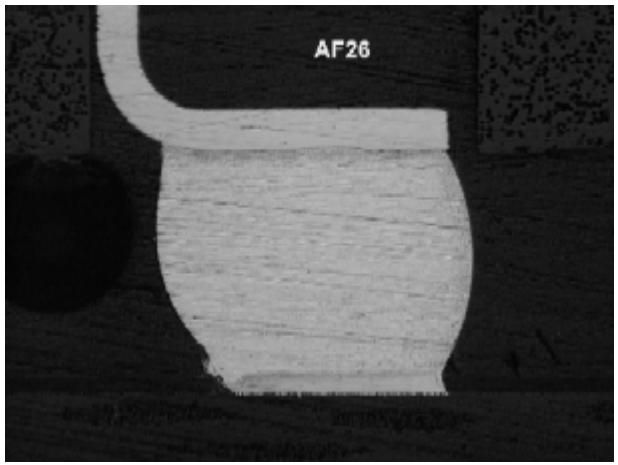
Heater Zone	1	2	3	4	5	6	7	8	9	10E	10I	Rail
Top Setting °C	155	175	170	160	160	165	180	205	237	235	235	220
Bottom Setting°C	155	175	170	160	160	165	180	205	237	235	235	220

SMT Process Recommendations

- Reflow considerations:
  - Temperature ramp minimizes warpage.
  - Sufficient dwell to equilibrate before peak temperature exposure
  - Proper peak temperature and dwell in liquid state
  - Temperature ramp down minimizes warpage.
- Post Reflow Inspection
  - BGA and other grid array packages are difficult to inspect. The best assurance is process control.
  - X-Ray is capable of consistently finding shorts between balls and voids
  - X-Ray cannot detect cold-solder joints or opens
  - X-Ray should be considered a development tool, not an HVM tool
    - » Measurement of ball collapse has a longer turn-around-time than X-ray, but is still a development or sampling tool.

SMT Process Recommendations

- Solder Joint Cross Section (BGA socket on a 20 mil pad)



SMT Process Recommendations

- Yield considerations:
  - Solder paste quality (uniform, no foreign material, not expired)
  - Motherboard preparation (clean, flat, good lands, good solder mask coverage)
  - Placement accuracy (within half of land diameter for BGA sockets)
  - Environmental (humidity/moisture, temperature control of factory floor)
  - Voids in ball joints are induced by the SMT assembly process, primarily by trapped flux in the solder paste.
  - The primary factors that increase the size and quantity of voids are the following:
    - » Higher average reflow temperature
    - » Increasing the metal content of the solder paste
    - » Higher solvent volatility in the solder paste
    - » Smaller metal powder size in the solder paste

Essentials for Quality Assembly

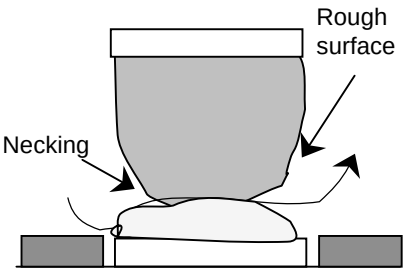
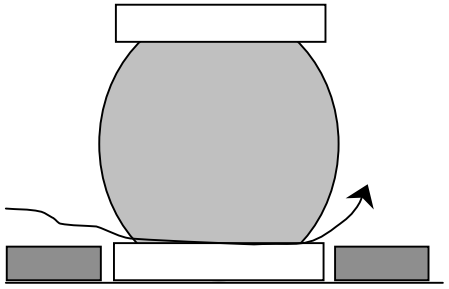
Essential Element	Recommendation
Solder Paste Quality	The solder paste should have uniform viscosity and texture and be free of foreign material
Solder Paste Storage	The solder paste should be used before the expiration date. Ensure that the paste is maintained at a proper temperature during shipment and is protected from drying out on the solder stencil
Motherboard	Use a clean, flat, well-plated solder ball land area and sufficient soldermask coverage
Placement Accuracy	Alignment marks (targets) on the PCB are helpful for placing parts. Ball recognition is recommended.
Moisture Sensitivity Precautions	Know the moisture sensitivity rating of your components and adhere to IPC/JEDEC moisture control conditions to avoid package delamination or cracking.

MA

Process and BGA Failure Containment Recommendations

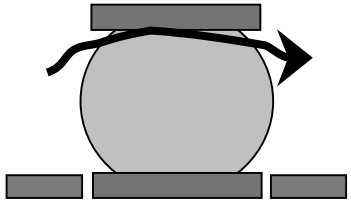
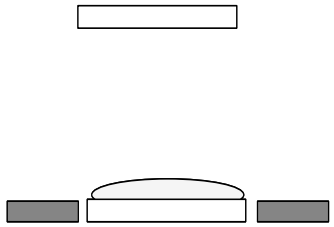
intel

MA

Type	Open Joint Signature	Illustration / Photo	Root cause
A	•Cold Solder Joint: Solder paste not reflowing to BGA ball •Appearance of necking with a rough BGA surface •Solder appears grainy and there is a difference between the BGA grain structure and solder paste grain structure (indication that paste did not reach proper reflow temperature)		•Low reflow peak temperature •DOE replicated failure signature with peak temp < 190 deg. C
B	•Non-solderable interface between PCB pad and BGA ball •PCB pad is not wettable/solderable to the BGA ball due to contamination on pad •Solder paste wetted to BGA ball, but not to PCB pad		•All failures in Intel factories have been due to non-POR rework at our PCB suppliers resulting in contaminated pads with soldermask •Solder pad oxidation, fingerprint contamination, and/or other organic contamination also possible

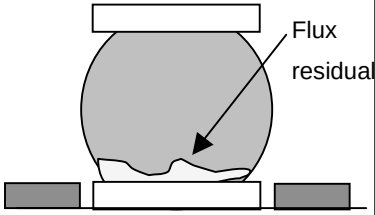
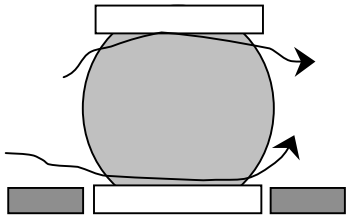
intel

MA

Type	Open Joint Signature	Illustration	Root cause
D	•Solder joint interface between the solder ball and the BGA component-side pad fails causing the BGA ball to "drop" creating elongated solder balls with rounded tops and/or flat tops	**Ball Drop** 	•Root caused to high topside wave temperature (exceeding 160 deg C) •Topside ICH2 BGA component solder balls are softening and/or melting (if topside temperature is hot enough) during the wave solder pre-heat process •Thermo-mechanical forces are causing the BGA component substrate to be pulled away from the board during the wave solder process •Excess surface tension during actual "wave solder" applied to a "softened" or melted BGA solder joint •These two factors occurring together are resulting in the BGA solder ball to dewet from the BGA component land and to "drop", creating the open joint
E	•Missing solder ball and/or undersized balls •Solder bump form on PCB pad •Clear separation btw BGA to solder bump, NO physical contact. Smooth BGA surface •Flux residual on top of solder bump surface.		•Ball not populated on array during BGA ball attach process •Ball "knocked-off" due to mechanical shear following packaging at component factory, but prior to placement on MB

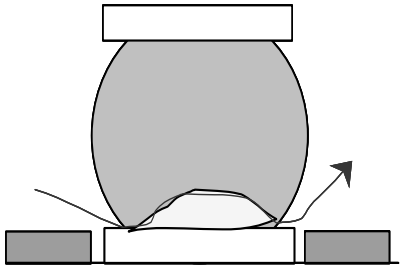
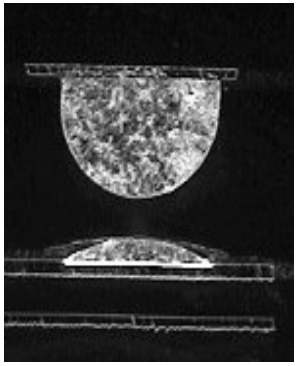
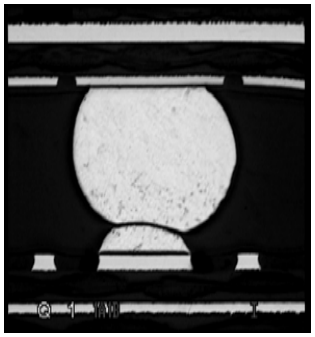
intel

MA

Type	Open Joint Signature	Illustration	Root cause
F	•The Type F failure signature upon cross section FA is flux residue on the BGA pad •No lateral shifting of the joints (as in Type H) •Upon pull testing, a crater-like solder joint is observed •Cross-section analysis indicates a bubbly or wavy like open solder joint •Peripheral and/or no solder observed on pad •> 90% of this defect mode occurs on solder mask defined pads		•Specific Root Cause not determined •Increased stencil volume (height) does not produce better results •Long soak time (145-183ºC) > 2 minutes seems to be primary contributing factor •Soak time and high coplanarity interaction does have a significant impact •Potentially contributions from paste volume, SM contamination, SM thickness, Oxidation •Many Defects are in the shadow of the die •Partial soldermask contamination doesn't cause a mode F signature
G	•Solder joints cracks evident within the BGA ball solder joint at either the BGA ball-component pad interface, the BGA ball-MB pad interface, or within the BGA ball itself		•Excessive mechanical stress during board level assembly or during customer chassis level assembly, causing solder joint cracking and open joint •Residual stress in solder joints following assembly, caused by package warpage during reflow, resulting in cracking upon additional mechanical stress following assembly

intel

MA

Type	Open Joint Signature	Illustration/ Photo	Root cause
H	•Solder paste reflowed properly and wetted to PCB pad •Solder ball reflowed properly and wetted to component pad •Interface between solder paste and BGA ball not wetted •In some cases, failed joints may be associated with elongated or column solder joints adjacent to the signature •Grain structure on board side is similar to BGA ball (properly formed reflowed solder) •Lateral shifting of the BGA with respect to the pad, is also present in some cases	  	•Specific root cause not determined yet •Potential root causes: •Organic contamination on BGA ball surface prior to reflow •Dynamic package warpage during reflow causes separation between the solder ball and solder paste resulting in excess flux at the interface (causing no wetting), or resulting in “no contact” at reflow temperatures

Process / Defect Containment Recommendations

- Oven reflow profile
  - Virtual profiling (ensure all boards are seeing the recommended profile, blower protection)
  - Gold board reflow profile created for product run at the time
  - Recommended Kester 244 Paste Supplier Profile Requirements:
    - Ramp rate: < 3.0°C / s
    - Soak time = 2.0 minutes max, 60-90s typical (145 – 183^{o}C)
    - Time above liquidus: 90s max, 40 to 60s typical
    - Peak temp = 205^{o}C – 225^{o}C Target 218^{o}C
- Disallow PCB supplier rework post HASL (Hot Air Solder Level)
  - No soldermask rework in BGA area

Process / Defect Containment Recommendations

- Maintain PCB solder mask thickness specification (0.4 → 2 mils)
- Minimize bare board handling during assembly (i.e. use gloves at screen print)
- Gold board IR mass reflow and Wave Solder profiles created for specific product platforms and solder processes. Use multiple thermocouples at critical points on PCB must be used.
- Insure all lines in factory running BGAs use the same CTF (Critical to Function) parameters
- Maximize ICT signal test coverage, recommended > 80%. (Applications note on the processor's boundary scan motherboard test feature pending.)
- Implement RFC (Response to Checklist) trigger limits for BGA opens at all test processes (Intel specific: 2 BGA opens in a 12 hour shift (ICT and FT) calculated control limits
- On-Going Reliability Test (non-destructive sampling)

MA

Processor Mount Rework - SRT Summit 1000/1100

- Customer must conduct experimentation to characterize, stabilize, and optimize its own process for processor removal from their motherboard
- It is recommended that the board not see more than two rework cycles on a product. Sockets should be discarded and replaced with new. Do not attempt to reuse the socket.
- A SRT customized nozzle should be used to rework the socket - drawing to be released
- Reflow profile development still in progress. Rework reflow profiles should be established with the thermocouple/profile board metrology.

intel

OEM Feedback on Socket SMT

Is Intel Validating the Correct Surface Mount Process?

Please provide areas that are inconsistent with your SMT process (see table below).

Surface Mount Parameter	**Intel's Reference Solution**	**Other Possible Solutions (Currently not being validated by Intel)**
Stencil	5 or 6 mil with a 1:1 aperture	Various thickness' and aperture sizes
Stencil Fabrication	Chemical Etch (electropoliish)	Laser
Solder Process	No Clean Process	Clean Process
Squeegee	Rubber	Metal
Socket Material Handling	Tape and Reel	Trays
Pick and Place	Vacuum Gripper	Mechanical Gripper
Vision Algorithm	Ball Recognition	Socket Outline
Oven Atmosphere	Nitrogen with <1000 O2 PPM level	Air, Nitrogen with XXX O2 PPM level
Metrology Systems	X-ray, Electrical test, SVS	Other Metrology Systems (4Pi)
Board Surface Finnish	HASL	Immersion silver, NiAu
Rework Cycles	2	> 2 cycles